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Claims:

1. A process for preparing aromatic compounds having a structural element of the formula I in the aromatic hydrocarbon ring,



where

M is -Li, -MgX₃, (C₁-C₁₈-alkyl)₃Sn-, -ZnX₃ or -B(O-C₁-C₄-alkyl)₂,

X₁ and X₂ are each, independently of one another, O or N and C-bonded hydrocarbon or heterohydrocarbon radicals are bound to the free bonds of the O or N atoms,

the group -C=C- together with carbon atoms forms a hydrocarbon aromatic and

X₃ is Cl, Br or I,

characterized in that an aromatic compound having a structural element of the formula II in the aromatic ring,



where X₁ and X₂ are as defined above and the group -C=C- together with carbon atoms forms a hydrocarbon aromatic,

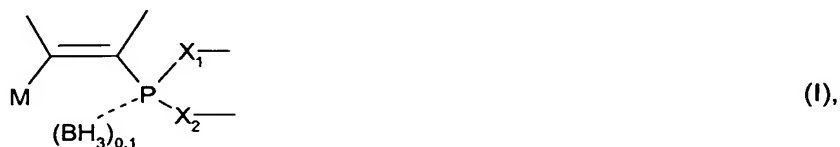
is reacted with at least equivalent amounts of alkyllithium, a magnesium Grignard compound or an aliphatic Li sec-amide or X₃Mg sec-amide, and, to prepare compounds of the formula I in which M is -MgX₃, (C₁-C₁₈-alkyl)₃Sn-, -ZnX₃ or -B(O-C₁-C₄-alkyl)₂, a lithium compound of the formula Ia,



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is reacted with at least equivalent amounts of $\text{Mg}(\text{X}_3)_2$, $\text{Zn}(\text{X}_3)_2$, $(\text{C}_1\text{-C}_{18}\text{-alkyl})_3\text{SnX}_3$ or $\text{B}(\text{O-C}_1\text{-C}_4\text{-alkyl})_3$.

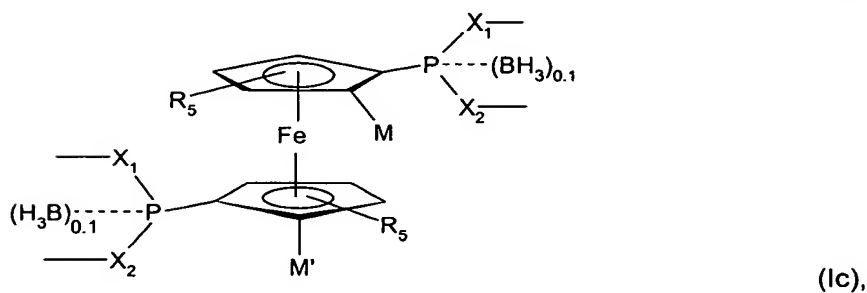
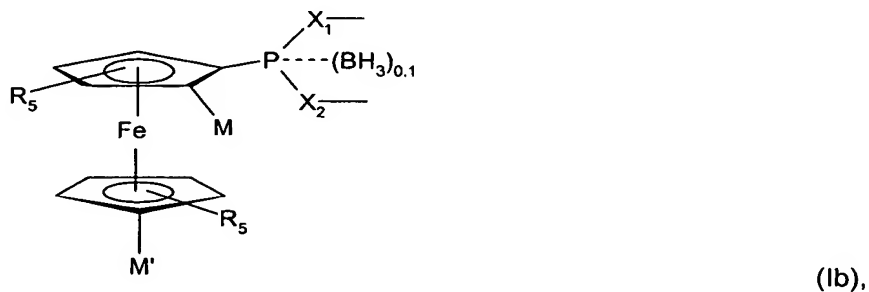
2. A compound having a structural element of the formula I in the aromatic hydrocarbon ring,



where

M, X_1 and X_2 are as defined in claim 1 and the group $-\text{C}=\text{C}-$ together with carbon atoms forms a hydrocarbon aromatic.

3. The compound as claimed in claim 2, characterized in that the compound of the formula I is a compound which has a ferrocene skeleton as aromatic compound and corresponds to the formula Ib or Ic,



where

R_5 is $\text{C}_1\text{-C}_4\text{-alkyl}$ and preferably a hydrogen atom,

M is $-\text{MgCl}$, $-\text{MgBr}$ and preferably Li,

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M' is H, -MgCl, -MgBr or Li and

X₁ and X₂ and also the radicals bound to free bonds of X₁ and X₂ have the meanings given in claim 1.

4. The compound as claimed in claim 2, characterized in that the compound of the formula I is a compound which has an arene skeleton as aromatic compound and corresponds to the formula Id,

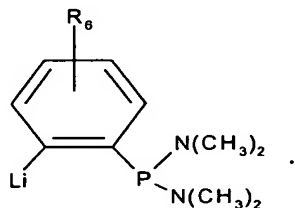


where

R₆ is C₁-C₄-alkyl and preferably a hydrogen atom,

M is -MgCl, -MgBr and preferably Li and

X₁ and X₂ and also the radicals bound to free bonds of X₁ and X₂ have the meanings given in claim 1, with the exception of ortho-lithiobis(dimethylamino)phosphinobenzene of the formula



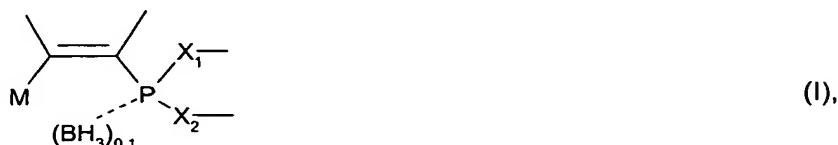
5. A process for preparing aromatic compounds of the formula III,



where

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X_1 and X_2 and also the radicals bound to free bonds have the meanings given in claim 1 and E is the radical of a reactive, electrophilic compound which is able to replace a metal bound to hydrocarbon aromatics or a bound metal group, characterized in that a compound of the formula I,



where

M, X_1 and X_2 and the radicals bound to free bonds have the meanings given in claim 1, is reacted with at least equivalent amounts of a reactive electrophilic compound.

6. A metallocene from the group consisting of ferrocene, bisindenylferrocene and ruthenocene having a structural element of the formula III in one or both cyclopentadienyl rings,

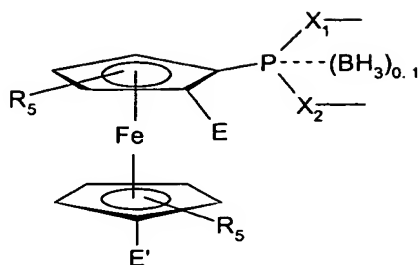


where

E, X_1 and X_2 and hydrocarbon radicals bound to the free bonds of the groups X_1 and X_2 have the meanings given in claims 1 and 5.

7. The metallocene as claimed in claim 6, characterized in that it corresponds to the formula IV,

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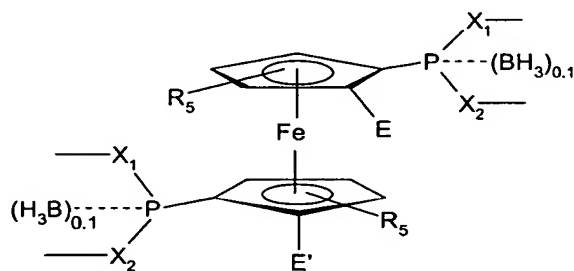


(IV),

where

R_5 is C_1 - C_4 -alkyl and preferably a hydrogen atom, E' is H or independently has one of the meanings of E, and E, X_1 and X_2 and hydrocarbon radicals bound to the free bonds of the groups X_1 and X_2 have the meanings given in claim 6.

8. The metallocene as claimed in claim 6, characterized in that it corresponds to the formula Iva,



(IVa),

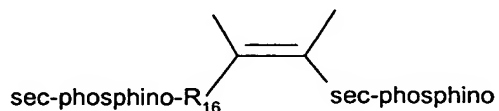
where

E' is H or independently has one of the meanings of E,

R_5 is C_1 - C_4 -alkyl and preferably a hydrogen atom and

E, X_1 and X_2 and hydrocarbon radicals bound to the free bonds of the groups X_1 and X_2 have the meanings given in claim 6.

9. A process for preparing hydrocarbon-aromatic diphosphines having structural elements of the formula VI in an aromatic hydrocarbon ring,



(VI),

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or having structural elements of the formula VIa in each cyclopentadienyl ring of a metallocene,



where

R_{16} is a direct bond or a divalent bridging group, with the sec-phosphino in the bridging group being located in the 1, 2 or 3 position relative to the carbon atom of the aromatic ring, and R_{17} is a substituent which is bound via a carbon atom to the aromatic ring, which comprises the steps:

a) reaction of an aromatic compound of the formula II



with metalation reagents to form an aromatic compound of the formula I



where M, X_1 and X_2 and hydrocarbon radicals bound to the free bonds of the groups X_1 and X_2 have the meanings given in claim 1,

b) reaction of the compound of the formula I with an electrophilic and reactive compound, wherein

b1) the compound of the formula I is reacted with a sec-phosphine halide to introduce sec-phosphino,

b2) the compound of the formula I is reacted with an electrophilic reactive compound which has a reactive group which can be replaced by sec-phosphino in the 1, 2 or 3 position and the product is subsequently reacted with a metal sec-phosphate or a secondary phosphine to introduce the group $-R_{16}$ -sec-phosphino,

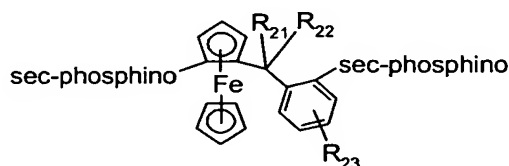
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b3) the compound of the formula I is reacted with an electrophilic organic compound which forms an α -carbon atom to introduce the group $-R_{17}$,

c) any borane group present is removed from the compounds obtained in steps b1), b2) or b3) and the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 are subsequently split off to form a $-PCl_2$ group or $-PBr_2$ group and the Cl or Br atoms are then replaced by a hydrocarbon radical by means of an organometallic compound to form the sec-phosphino group, or

d) the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 are split off to form a $-PCl_2$ group or $-PBr_2$ group and the Cl or Br atoms are then replaced by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group and the borane group is then removed.

10. The process as claimed in claim 9 for preparing 1-(α -substituted ortho-sec-phosphino-benzyl)-2-sec-phosphinoferrocenes of the formula VII in the form of their racemates, mixtures of diastereomers or essentially pure diastereomers,



(VII),

where

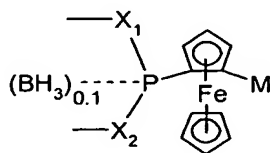
R_{21} is hydrogen, C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl, unsubstituted or F-, C_1 - C_6 -alkyl- or C_1 - C_6 -alkoxy-substituted phenyl or benzyl,

R_{22} is C_1 - C_4 -alkoxy, C_1 - C_8 -acyloxy or sec-amino and

R_{23} is hydrogen, C_1 - C_4 -alkyl or C_1 - C_4 -alkoxy,

which comprises the steps:

a) reaction of a compound of the formula VIII

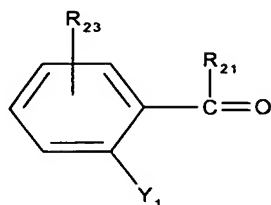


(VIII),

where

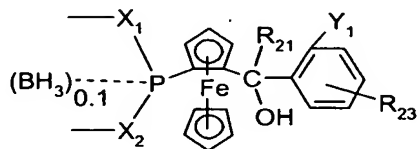
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M and the group $-P(X_1)(X_2)---(BH_3)_{0.1}$ are as defined in claim 1, with a compound of the formula IX



(IX),

where Y_1 is Cl, Br or I and R_{23} and R_{21} are as defined in claim 1, to form a compound of the formula X,

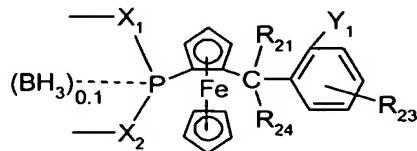


(X),

- b) C_1 - C_4 -alkylation or C_1 - C_8 -acylation of the OH group in the compound of the formula X or replacement of the acyloxy group formed by sec-amino,
- c) replacement of the halogen Y_1 in compounds of the formula X by sec-phosphino and subsequent conversion of the group $-P(X_1)(X_2)---(BH_3)_{0.1}$ into a sec-phosphino group, or conversion of the group $-P(X_1)(X_2)---(BH_3)_{0.1}$ firstly into a sec-phosphino group and subsequent replacement of the halogen Y_1 in compounds of the formula X by sec-phosphino,
- d) preparation of the diphosphine of the formula VII, by
 - d1) removing any borane group present from a compound of the formula X, then splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group, or
 - c2) splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group and then removing the borane group.

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11. A compound of the formula XI in the form of a racemate, diastereomer or pair of diastereomers,

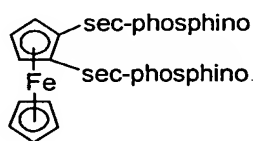


(XI),

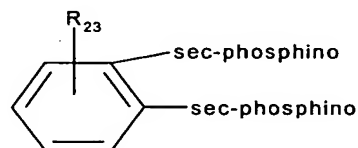
where

the group $-P(X_1)(X_2)---(BH_3)_{0.1}$, R_{21} , R_{23} and Y_1 are as defined in claims 1 and 10, or (X_1-) and (X_2-) in the group $-P(X_1)(X_2)---(BH_3)_{0.1}$ are Cl or Br, and R_{24} is -OH, C_1 - C_4 -alkoxy, C_1 - C_8 -acyloxy or sec-amino.

12. The process as claimed in claim 9 for preparing compounds of the formula XII in the form of racemates, diastereomers and pairs of diastereomers and also compounds of the formula XIII,



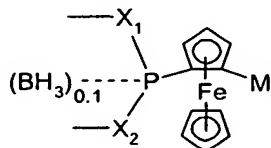
(XII),



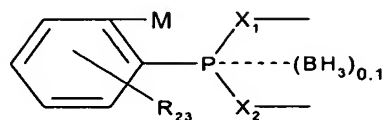
(XIII),

which comprises the steps

a) reaction of a compound of the formula XIV or XV



(XIV),

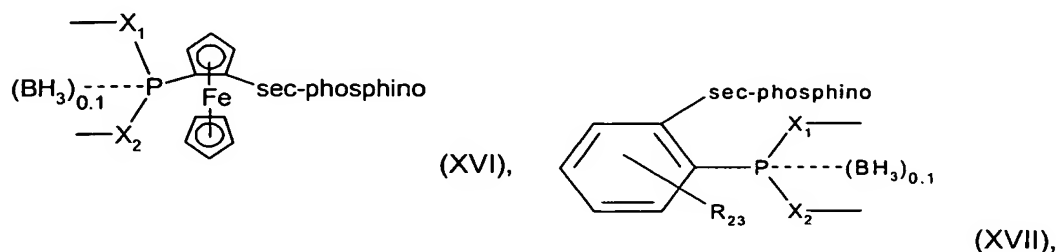


(XV),

where

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M, R_{23} and the group $-P(X_1)(X_2)---(BH_3)_{0.1}$ are as defined in claims 1 and 10, with a sec-phosphino halide (chloride or bromide) to produce compounds of the formula XVI or XVII,

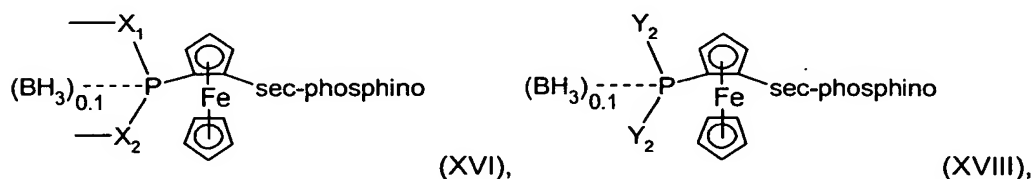


b) preparation of diphosphines of the formulae XII and XIII by

b1) removing any borane group present from a compound of the formula XVI or XVII, then splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group, or

b2) splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group and then removing the borane group.

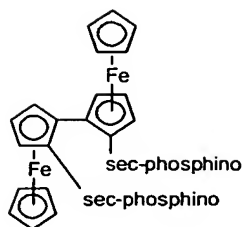
13. A compound of the formula XVI or XVIII in the form of a racemate, diastereomer or pair of diastereomers,



where the group $-P(X_1)(X_2)---(BH_3)_{0.1}$ is as defined in claim 1 and Y_2 is Cl or Br.

14. The process as claimed in claim 9 for preparing compounds of the formula XIX in the form of racemates, diastereomers and pairs of diastereomers,

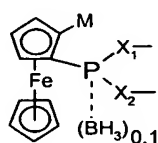
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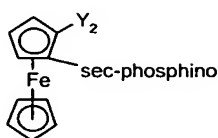
(XIX),

which comprises the steps

a) reaction of a compound of the formula XX with a compound of the formula XXI,



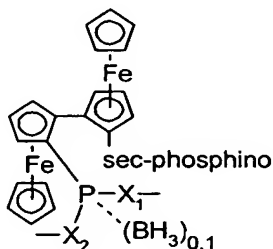
(XX),



(XXI),

where

M is $-\text{Sn}(\text{C}_1\text{-C}_4\text{-alkyl})_3$ or $-\text{ZnX}_3$, the group $-\text{P}(\text{X}_1-)(\text{X}_2-)\text{---}(\text{BH}_3)_{0.1}$ is as defined in claim 1 and Y_2 is I or Br, in the presence of a Pd catalyst to form a compound of the formula XXII



(XXII),

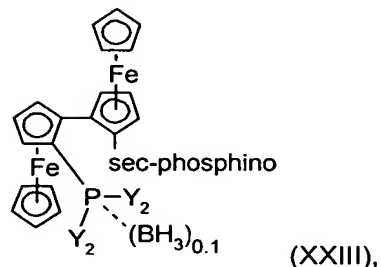
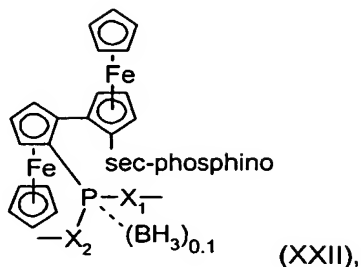
b) preparation of diphosphines of the formula XIX by

b1) removing any borane group present from a compound of the formula XXII, then splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-\text{PCl}_2$ group or $-\text{PBr}_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group, or

b2) splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-\text{PCl}_2$ group or $-\text{PBr}_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group and then removing the borane group.

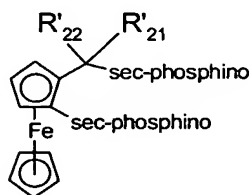
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15. A compound of the formula XXII or XXIII in the form of a racemate, diastereomer or pair of diastereomers,



where the group $-P(X_1)(X_2)---(BH_3)_{0.1}$ is as defined in claim 1 and Y_2 is Cl or Br.

16. The process as claimed in claim 9 for preparing compounds of the formula XXIV in the form of racemates, diastereomers and pairs of diastereomers,



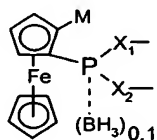
where

R'_{21} is hydrogen or C_1 - C_6 -alkyl,

R'_{22} is C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl, unsubstituted or F-, C_1 - C_6 -alkyl- or C_1 - C_6 -alkoxy-substituted phenyl or benzyl,

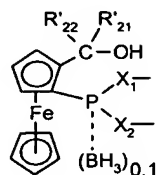
which comprises the steps

a) reaction of a compound of the formula XX,



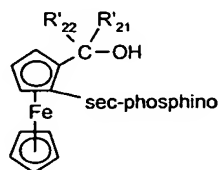
with an aldehyde or ketone of the formula $R'_{21}R'_{22}C(O)$ to form a compound of the formula XXV,

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(XXV),

b) preparation of compounds of the formula XXVI,



(XXVI),

by

b1) removing any borane group present from a compound of the formula XXV, then splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group, or

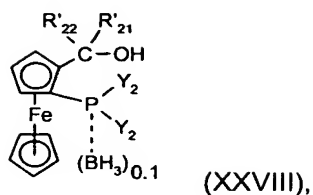
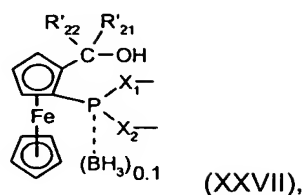
b2) splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group and then removing the borane group,

c) acylating the compound of the formula XXVI, for example by means of a carboxylic anhydride, and

d) replacing the C_1 - C_8 -acyloxy group formed by means of a secondary phosphine to give compounds of the formula XXIV.

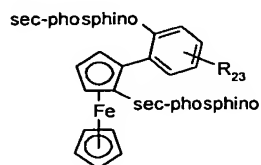
17. A compound of the formula XXVII or XXVIII in the form of a racemate, diastereomer or pair of diastereomers,

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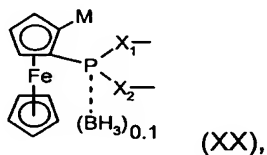
where R_{21} and R_{22} are as defined in claim 16, Y_2 is Cl or Br and the group $-P(X_1)(X_2)---$
 $(BH_3)_{0.1}$ is as defined in claim 1.

18. The process as claimed in claim 9 for preparing compounds of the formula XXIX in the form of racemates, diastereomers and pairs of diastereomers,

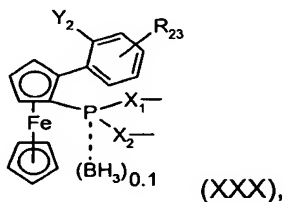


which comprises the steps

a) reaction of a compound of the formula XX



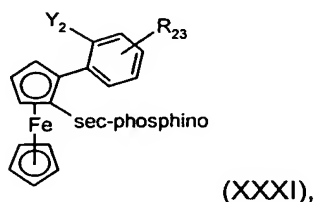
where M is $-\text{Sn}(\text{C}_1\text{-C}_4\text{-alkyl})_3$ or $-\text{ZnX}_3$, the group $-P(X_1)(X_2)---$
 $(BH_3)_{0.1}$ is as defined in claim 1, with 1-bromo-2-iodobenzene or 1,2-diiodobenzene in the presence of a Pd catalyst to form a compound of the formula XXX,



where Y_2 is bromine or iodine,

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b) to prepare monophosphines of the formula XXXI

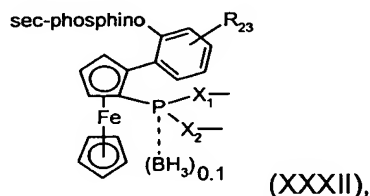


b1) removing any borane group present from a compound of the formula XXX, then splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group, or

b2) splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group and then removing the borane group, and

c) then replacing the bromine or iodine atom by a sec-phosphino group by metalation by means of a lithium alkyl (butyllithium) and subsequent reaction with a sec-phosphine halide, or

d) to prepare compounds of the formula XXXII



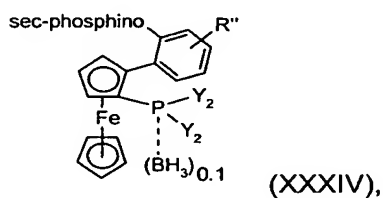
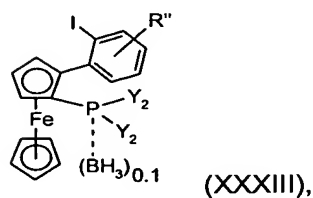
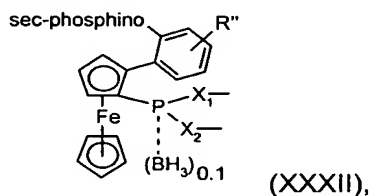
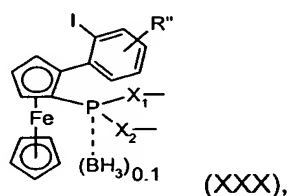
reacting a compound of the formula XX with ortho-sec-phosphinophenyl iodide in the presence of metal halides such as $ZnBr_2$ and Pd catalysts, and

d1) removing any borane group present from a compound of the formula XXXII, then splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group, or

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d2) splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group and then removing the borane group.

19. A compound of the formula XXX, XXXII, XXXIII or XXXIV in the form of a racemate, diastereomer or pair of diastereomers,



where the group $-P(X_1)(X_2)---(BH_3)_{0.1}$ is as defined in claim 1, Y_2 is Cl or Br and R'' is hydrogen or a substituent.

20. The process as claimed in claim 9 for preparing compounds of the formula XXXV in the form of racemates, diastereomers and pairs of diastereomers,



where

R_{24} is a radical of the formula $-CR_{25}R_{26}-Y_3$ or a group R_{28} .

R_{25} is hydrogen, C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl, unsubstituted or F-, C_1 - C_6 -alkyl- or C_1 - C_6 -alkoxy-substituted phenyl or benzyl,

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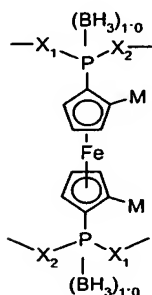
R₂₆ is C₁-C₆-alkyl, C₃-C₈-cycloalkyl, unsubstituted or F-, C₁-C₆-alkyl- or C₁-C₆-alkoxy-substituted phenyl or benzyl,

Y₃ is C₁-C₄-alkoxy, C₁-C₆-acyloxy or sec-amino and

R₂₈ is C₁-C₆-alkyl, C₃-C₈-cycloalkyl, unsubstituted or F-, C₁-C₆-alkyl- or C₁-C₆-alkoxy-substituted phenyl or benzyl,

which comprises the steps

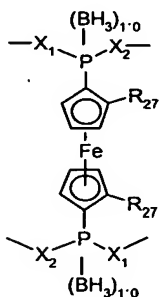
a) reaction of a compound of the formula XXXVI



(XXXVI)

where

the group -P(X₁)(X₂)-(BH₃)_{0.1} is as defined in claim 1, with an aldehyde or ketone or imine of the formula CR₂₅R₂₆=Y₄, where Y₄ is =O or =N(C₁-C₄-alkyl), or with a halide R₂₈Y₆, where Y₆ is Cl, Br or iodine, to form compounds of the formula XXXVII



(XXXVII),

where

R₂₇ is the group -CR₂₅R₂₆-Y₅ or R₂₈, where R₂₅ and R₂₆ are as defined above and Y₅ is -OH or -NH(C₁-C₄-alkyl), alkylating the NH group, if appropriate alkylating or acylating the OH group and, if appropriate, replacing the acyloxy group by sec-amino and

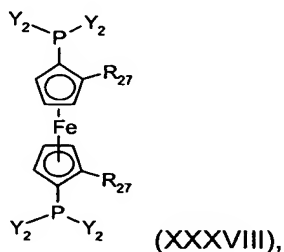
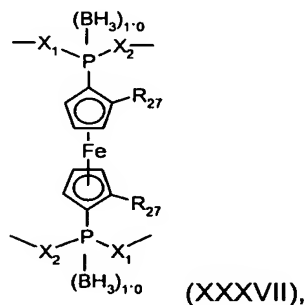
b) to prepare compounds of the formula XXXV

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b1) removing any borane group present from a compound of the formula XXXVII, then splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group, or

b2) splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 to form a $-PCl_2$ group or $-PBr_2$ group and then replacing the Cl or Br atoms by a hydrocarbon radical by means of an organometallic compound (Grignard reagent) to form the sec-phosphino group and then removing the borane group.

21. An intermediate in the form of a racemate, diastereomer or pair of diastereomers, in particular an intermediate of the formula XXXVII or XXXVIII,



where

R_{27} and Y_2 are as defined in claim 1 and the group $-P(X_1)(X_2)-(BH_3)_{0.1}$ is as defined in claim 1.